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THE BRAZILIAN REPORT TO THE 7TH LANDSAT TECHNICAL WORKING GROUP (LTWG) MEETING

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14. Abstract/Notes

This document describes the current status of the INPE LANDSAT receiving and processing facilities, as well as the experience in the related activities during the period from June 1984 to February 1985.

15. Remarks

Prepared for presentation at the 7th LTWG Meeting held at Williamsburg, U.S.A., from February 26 to March 01, 1985.

CHAPTER 1

CONFIGURATION AND STATUS

INPE's Landsat system is split into two sites. The Receiving Station is located in Cuiaba, Mato Grosso, due to its geographic position which favors the best coverage of Brazil and South America; the Processing Station is in Cachoeira Paulista, São Paulo, closer to the resources offered by the Rio-São Paulo region. The tapes recorded at Cuiabã are sent to Cachoeira Paulista by plane.

1.1 - RECEIVING STATION

The present configuration at Cuiabã can be divided into four different functional subsystems:

- Tracking and receiving subsystem, including:

  . one 9-meter parabolic antenna for S-band, with associated tracking and receiving equipment (Scientific Atlanta), installed in 1973;

  . one 10-meter parabolic antenna in cassegrain configuration for simultaneous S and X-band reception, with associated tracking and receiving equipment (Scientific Atlanta), installed in September, 1982.

- Recording subsystem, including:

  . one paralell 28-track wideband recorder (Ampex FR-1928) for MSS, installed in 1973. Up to 2 satellite passes are recorded onto one 7200' tape;

. one serial-in-serial-out 28-track high density digital recorder (Martin-Marietta) for MSS or TM, installed in February, 1983. Up to 2 TM passes or 6 MSS passes are recorded onto one 9200' tape;

. one analog 4-track instrumentation recorder (Hewlet-Packard) for telemetry data, installed in 1973. Up to 2 passes (8 Kbps) or 5 passes (1 Kbps) are recorded onto one 2400 x .25" tape;

. one serial-in-serial-out 14-track high density digital recorder (Martin-Marietta) for MSS, installed by NASA to support the Backup Plan.

- Data monitoring subsystem, including:

. an INPE-built hardware allowing simultaneous display of the six MSS sensors from any band in analog form onto an oscilloscope CRT;

. a COMTAL black-and-white visualization system with a 512 x 512 screen allowing real-time or playback monitoring of TM video data in a moving-window fashion.

- Computer subsystem, based on a DEC PDP-11/34 minicomputer and peripherals, performing:

. generation of antenna pointing data printouts for satellite initial acquisition or manual reacquisition;

. real time support of the antenna tracking as a secondary mode, in case of autotrack loss or malfunction;

. downline loading of the COMTAL application software.

The Receiving Station is operational for both MSS and TM and both S- and X-bands, and has been recording MSS data from Landsats 4 and 5 over full acquisition range since launch. TM data are being received and recorded regularly since April 6, 1984.

1.2 - PROCESSING STATION

The present configuration at Cachoeira Paulista is best described if grouped by the instrument(s) to be processed:

- The old MSS/RBV processing subsystem integrated and installed by Bendix Aerospace in 1974, built around two DEC PDP-11/15 minicomputers and peripherals, including:

  . one paralell 28-track wideband recorder (Ampex FR-1928) for the playback of MSS data, and its special interface equipment (Bendix Aerospace) capable of extracting from the incoming stream and routing to the minicomputers through separate lines the video, auxiliary data such as Time and Line Length codes, and synchronization signals;

  . one 70mm film Electron Beam Recorder (CBS) and special interface equipment (Bendix Aerospace) including D/A converters and geometric corrections circuitry to allow the computers to geometrically correct the images without the need for resampling;

  . one analog 4-track instrumentation recorder (Hewlett-Packard for playing back telemetry data;

  . one modified VT recorder (RCA TR-70) for RBV playback, and its special interface (Synaptic Systems) to DC-restore the video and route it directly to the analog circuitry of the Electron Beam Recorder, at the same time sending sync pulses to the minicomputers to allow synchronization with the geometric and radiometric (de-shading) corrections;

. one RAMTEK visualization equipment with a 256 x 640 color monitor allowing display of MSS video from either the wideband recorder (through the computer) or CCTs;

. one digitizer table (Bendix) for measuring X-Y coordinates to support either systematic calibration of the EBR with grid patterns or the generation of precision products based on Ground Control Points identified on bulk imagery;

. one Quick-Look equipment (Celco), connected directly to the MSS recorder, allowing the production of low-resolution, uncorrected imagery without computer interference, via a camera coupled to a CRT.

This subsystem is operational but the mean time between failures is decreasing due to age. It has received the addition of two new magnetic tape units to support CCT production with increased reliability. Anyhow, the most critical equipments (the Ampex recorder and the EBR) are unfortunately the hardest ones to replace.

- The new TM processing subsystem, integrated and installed by Société Européenne de Propulsion (SEP) in December, 1983, with the final acceptance tests concluded in February, 1984. This subsystem is built around a DEC VAX-11/780 and peripherals, and includes:

  . one serial-in-serial-out HDDR (Martin Marietta) for playback of the TM tapes, and dedicated acquisition chain (Enertec) including a format sync/decom and a programmable demultiplexer. The chain is controlled by an LSI-11 microprocessor and communicates with the computer and with the COMTAL system below, providing video, status and auxiliary data;

. one COMTAL Color visualization system with a 512 x 512 screen, interactive keyboard and trackball, connected to the VAX and to the subsampled output port of the acquisition chain. This system supports the production of Quick-Look imagery (through a slave flatscreen display connected to the monitor and coupled to a Hasselblad camera) and also the interactive image manipulation facilities (contrast stretch, edge enhancement etc.) available in the processing system. These facilities operate over images previously loaded into the 256-MB disk dedicated to this role;

. one 5-inch film Electron Beam Recorder and special interface equipment (Image Graphics Inc.). This EBR is a second-generation device capable of both raster and vector drawing, with geometric fidelity rated at .01% and extended geometric corrections capability.

The software of the VAX system (developed jointly by SEP and INPE) incorporates both production and management functions, handling the creation and updating of an acquired + processed images data base, allowing inquiries and production scheduling based on user requests entered into the system.

Besides the two processing subsystem above, there is a DEC PDP-11/34 minicomputer system, installed in 1978, supporting the management of the MSS and RBV data bases, as well as the inquiries and orders related to these instruments. It hosts also the geometric correction auxiliary functions for the production of Bulk and Precision photographic MSS imagery (this latter is fully operational since early 1983).

During November and December 1984 the Processing Station underwent the installation of some cartographic equipment of the Zeiss line to support Cartographic applications activities and extend the scope of the MSS Precision products line. The equipment includes measuring and plotting devices, as well as monostereo comparator and a rectifier-enlarger.

CHAPTER 2

EXPERIENCE IN ACQUISITION AND PROCESSING OF LANDSAT 4/5 DATA

2.1 - RECEIVING AND RECORDING

A few points deserve special notice in this area:

- The "assisted tracking" implemented in the PDP-11/34 has not been necessary due to the absence of autotrack losses in normal operation. The employed model, however, has demonstrated superb performance in tests conducted by turning off the tracking receiver after the initial satellite acquisition. The computer took over controlling the antenna without loss of a single dB in the payload signals.

- The telemetry recorder had to be adapted to the new data rate of 8 Kbps by using biphase instead of FSK recording.

- Landsat-4 TM data was never received due to the early failure of the TM transmitters. MSS was received and recorded with no problem.

- Landsat-5 TM is being routinely received and recorded since April '84, over the whole Brazilian territory (about 385 scenes/cycle). Due to the higher cost of recording and storing TM data, recording over other countries is made under special request only.

- Due to severe need of reducing expenses, MSS data also started being recorded only over Brazil since December, 1984. Recordings are normally made for Landsat-5 only, except over special areas where an 8-day repeat cycle is requested (for instance, the monitoring of the filling up of a hydroelectric power plant reservoir).

2.2 - PROCESSING

2.2.1 - MSS

Some problems faced in the processing deserved special attention:

- Some hardware modifications had to be carried on the MSS format sync equipment to accept the new S/C identification code inserted into the Time Code format.

- An old problem affecting all 24 MSS detectors was solved when it was noticed that with Landsat 4 the rate of its occurrence was considerably higher. This led to associate this problem with the increased Doppler effect due to the lower altitude of the satellite and trace it down to occasional single-bit losses at the Demultiplexer in Cuiabá. Another modification in the MSS format sync equipment corrected this problem for the processing.

- As in Cuiabá, the telemetry recorder had to be adapted to the new data rate of 8 Kbps. A modification in the recorder interface to the computer had to be implemented, as well as a rather deep change in the decommutation software.

- A heavy "woodgrain effect" associated with detector coherent background noise was observed on Landsat-4 MSS data.

2.2.2 - TM

During the Final Acceptance tests, in the period from December/1983 to February/1984, several performance tests were conducted. Concerning geometric fidelity, it is worth to mention the results achieved in the geometric internal accuracy test. As a test image, the Toledo-Detroit Landsat-4 scene of July 25, 1982 was selected. The system geometric corrections were derived analytically and applied to the Electron Beam Recorder, benefiting from its ability to accept real-time

corrections directly on its X-Y deflection circuitry. The full model (including jitter) was implemented into a UTM projection and 50 well-distributed geodetic GCPs were identified and measured. After removal of translational and rotational errors with respect to the UTM grid, the following encouraging performance data were verified:

Scale deviation	: .03%
RMS error in Easting	: 29.1 meters
RMS error in Northing	: 24.6 meters
RMS error (total)	: 38.1 meters

Note that this is just a system-corrected image!

From March to May/84, effort has been spent, mainly in the software area, to adjust the embedded satellite/instrument parameters to the new Landsat-5-specific coefficients/characteristics. Changes have also been made on the production routines towards a greater operationality when routinely processing real data onto Quicklook or high resolution EBR images, at real time rates.

On April/84 production of preliminary TM imagery was initiated in the high resolution film recorder with the main purpose of evaluating radiometric and geometric quality as well as image appearance.

During the preliminary production phase, some apparent anomalies were observed:

- A banding effect in phase with scan rate, visible mainly on uniform radiance areas, has been seen and thought to be related with the Scan Line Corrector performance. It was not observed in the Detroit image, at 40 degrees North latitude. This problem is still being studied to confirm or not this possibility. In the meantime, images are being processed with a geometric correction level slightly lower, to force parallelism between forward and reverse scans. This has eliminated the banding effect without causing noticeable local distortions.

- A severe along-line shift between forward and reverse scans can be observed in band 6 (thermal). This problem was due to incorrect values published for the sensor delays. It was cleared with Revision 8 of the Landsat to Ground Stations Interface Description document.

- Concerning radiometric performance, a definite need has been felt for some kind of contrast stretch treatment on data of most TM bands prior to processing them onto film. The attempt to process these bands to film without such enhancements has resulted into very flat images with poor image detail. This situation is aggravated due to the linear gamma transfer function presently in use in the EBR. All bands, except 4 and 5, will require special look-up tables derived to accomodate the average radiance excursion of each band within the most favorable dynamic range of the film but avoiding, as much as possible, cutoff or saturation of the data. The intention is to combine linear look-up tables in the computer with a nonlinear gamma transfer function at the EBR to achieve this improvement. In this preliminary phase, tests are being conducted to select the best gain and offset combination for each band for the use of linear look-up tables alone. The nonlinear gamma transfer function on the EBR will be implemented in the near future, and new gain-offset pairs may be required then.

Imagery distribution to users started on August, 1984.